ON THE FERTILIZATION OF CASSIA MARILANDICA.

BY THOMAS MEEHAN.

The relation of insects to flowers continues to be a question of profound interest. It has never been clear to my mind that insects are any material aid to plants through the pollinization which they often undoubtedly accomplish. There has been little to prove that in-and-in or close breeding is an injury; and it has been assumed that cross-breeding among plants must be a benefit, solely because arrangements for its accomplishment surely exist. I have shown in various papers (see chiefly *Proceedings of American Association for the Advancement of Science*, Detroit meeting), that in a scheme of nature for progressive development there must be provided arrangements for the removal of old as well as for the introduction of new forms, and from the facts adduced we have as much right to look on them in the light of agencies for removal as for the strength and preservation of a race. In my mind, the facts rather show that instead of any material aid to the propagation of the race being gained, the dependence of a plant on insect aid for fertilization is rather an indication that its race is nearly run, and that it is on the downward track in the order of nature.

The assumption that cross-fertilization is a factor in development instead of in degradation, has, I believe, been an injury to the study of the main question, as it has led to generalizations that cannot be sustained, and to assertions regarding facts that I think would not have been made had not the observers been prepossessed in favor of this hypothesis. The followers of those who have done so much to advance this branch of science, have gone much further in their speculations than those who first originated the line of thought; and even the leading minds in that path have often been the victims of an enthusiasm of which their cooler moments would not approve. Here and there we meet with statements by even such eminent naturalists as Darwin and Asa Gray, that would seem to sustain the wide genralizations of Grant Allen or Sir John Lubbock; but a careful study of their writings will show that they look on cross-fertilization as a fact, and as a measure of race utility, from a much more limited field

than the supporters of the wider speculations seem to believe. It is not the most eminent writers who assert that "cross-fertilization is the general rule," "the greater number of flowers are cross-fertilized," etc. (see *Popular Science Review*, 1873), though the casual expression of Dr. Asa Gray, in his papers of 1877, that "many flowers freely self-fertilize," certainly might imply self-fertilizers to be a minority of the whole; but the same eminent botanist has also said "it is a common case that flowers cross-fertilize when duly served by insects or wind, and self-fertilize when not," and this by no means bears the impression that he regards self-fertilizing flowers as composing a particularly limited class. Indeed no one is more severe than Dr. Gray on theory-makers who run off in haste on one line of facts. The true sentiments of Dr. Gray are that "cross-fertilization, we may well believe, is a very risky affair," and in view thereof very few plants have become wholly dependent on this mode, but act on the rule to prefer cross-fertilization "if they can," but failing in this, to self-fertilize, "if they must." And, though it is not so generally understood, I think a careful study of Mr. Darwin's works will show that this is essentially his view also.

Though unwilling to concede that any material benefit comes to the races of plants from the aid which insects give to plants by cross-fertilization, the fact that some species are evidently wholly dependent on this agency for fertility, is no less interesting, and any original observations must have value to the student of this branch of science.

Cassia, in a general way, has been a subject of study. In 1875 Dr. Leggett writes (Bull. Torr. Club, p. 171) that Dr. Torrey had noticed the difficulty *Cassia nictitans* had in rejecting its pollen. Dr. Torrey believed, however, that though the anthers seemed to provide a pore at the apex for the emission of pollen, they finally slit longitudinally, and thus permitted the pollen to escape. Dr. Leggett does not seem satisfied of this. In 1882, however, Prof. J. E. Todd published some extremely interesting observations on this species, and on *Solanum rostratum*, which has a similar staminal arrangement (see *Am. Naturalist.* Ap. 1882, p. 281–287). *C. Marilandica* is referred to as one that would probably behave in the same way. Before noting what Mr. Todd saw in these, I will note the observations I have made on this species.

As nothing seems to have been placed on record in relation to

Cassia Marilandica, and I having a good opportunity for daily observation, I undertook its close investigation this year. In *Cassia Marilandica* the flower consists of five petals, as in other leguminosæ; but the two which usually unite and form the carina are here distinct and spread widely, taking the place apparently often occupied by the wing-petals. The two actual wing-petals are somewhat erect and lap under the upper or vexillum. This arrangement gives the flower a "somewhat two-lipped appearance." The style curves gradually, but more rapidly at the apex, curving there so much that the stigmatic surface can scarcely be closely examined without breaking the style. If the petals be opened just before the natural time for their expansion, a globule of liquid is pendant from the surface. The stamens are arranged in separate sets. There are three beneath the pistil—the two lateral ones are very strong and equal the pistil in length—the central one immediately beneath the pistil is as long as those on each side, but more slender. Immediately above the pistil are four stamens, with short, stout filaments, the anthers being perfectly formed, and nearly as long as in the lower set. Above are three petaloid stamens, which we can only see are staminal efforts, by noting the intermediate stages of the several parts between the stamens and petals. The only use for them seems to be to afford a good morphological lesson to the student.

The most interesting feature of this *Cassia* is that the stamens, not mono or diadelphous as in many leguminosæ, have long, black anthers, full of pollen, but which seem never to burst the anther cases. The only "opening is at the apex," and this "opening" is covered by a membrane—never opening, as I believe, except by insect agency.

As soon as the flower expands it is freely visited by humble bees, and, as their loaded thighs evidence, for the pollen. To collect this, they alight on the anthers of the long and lower stamens, as on a platform—make an opening in the apex of each of the four shorter ones, and then rifle them of their contents. I watched a mass of plants containing eighty-eight flower stems, on the 30th of July, and the same lot for an hour on 6th of August, but saw no attempt to get pollen from the longer anthers, or to use them in any way but as a platform. It would, indeed, be hardly possible for the bee to stand anywhere so as to get power to pierce the apical membranes of the longer stamens. When the

flower matured, and the anthers were ready to fall, they were examined—the four short ones were empty sacs—the three lower ones proved they had not served any purpose to the bees, for they were full of pollen. There could be no doubt that, perfect and full of pollen as they were, they served no purpose that I could see either to the flower or to its insect visitors. Hive bees on honey-collecting expeditions hunted around among the base of the petals, but were not, apparently, well rewarded for their work. No pollen could be detected on the stigmatic surface; but as about three out of every twelve flowers yielded a pod, they were evidently fertilized in some way. On the 30th of July I covered one panicle that had not yet opened a blossom, with a gauze bag twelve inches wide and eighteen inches deep, tied at the bottom to prevent ingress. Not one of these enclosed flowers produced a seed vessel, nor could I see that any one anther "opened at the apex." The membrane covered it as completely as it did in the unopened flower.

Now all these observations confirm those of Mr. Todd in the other plants except in the following particulars: As in my case, he found that the bees never attempted to collect pollen from the longer and lower anthers, but "by the movement of her feet the larger stamen is repeatedly sprung backward, and as often throws a cloud of pollen on one side of her body." I am sure no pollen was ejected in this way from *Cassia Marilandica*, for the membrane at the apex was not even ruptured when the stamens were ready to fall. In regard to the manner in which the pollen is extracted, he found that "this she does by seizing each anther near its base between her mandibles, and, with a sort of milking motion, crowds the pollen out of the terminal pore." If this were the general way there would be no necessity for any pollen being ejected from the long stamens, for the stigma would certainly receive some during the "milking" process; and the pore at the apex in the long anther is beyond the line of the stigma, so that on ejection from the pore the pollen would go still further beyond. At any rate I am satisfied that in this species the anther cases did not under my observation ultimately split longitudinally, as stated by Dr. Torrey in an allied species, nor was there any drawing out of the pollen, as observed by Prof. Todd. It is abstracted solely through the pores; and although I could see no evidence that such was actually the case, I suspect

fertilization could only occur through some of this extracted pollen escaping from the insect to the stigma.

However, the fact was clearly demonstrated that *Cassia Marilandica*, in this experiment, does not produce a single seed, when the flowers are protected from the visits of insects.

This plant is the more interesting as it belongs to an order which the enthusiasts to whom I have referred, see "from its structure" to be so well "arranged for cross-fertilization," but which those who, like the following author, have followed results, see just the reverse. "To the casual observer of typical structures the papilionaceous plants must present the most difficult nut to crack for a student of cross-breeding. * * * As might be expected from the structure of the flowers, we have in these plants persistent examples of self-fertilization, and hence the constancy of garden varieties" (*Gard. Mag.*, Feb. 3, 1877).